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Latent Class Analysis of Student Preferences for Teaching Styles in Mathematics Education at a College of Education in the Volta Region, Ghana

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Abstract
The purpose of the study was to investigate the preference of teaching styles of student teachers in learning mathematics This study employed a quantitative research approach using a descriptive survey design to explore the impact of teaching styles on mathematics learning among level 400 student teachers in three Colleges of Education in the Volta region of Ghana. The participants were purposively sampled to identify their preferred learning styles in mathematics. Out of 1489 students, 1338 (89.86%) successfully submitted their questionnaires, making them the final sample for analysis. The instrument, Student Preference for Learning Mathematics Questionnaire (SPLMQ), consisted of 10 items measured on a three-point Likert scale (Disagree, Don't Know, Agree) was used. Data analysis included fit indicators, Latent Class Analysis (LCA) plots, descriptive statistics, and inferential statistics, including a one-way ANOVA (Welch's) and Games-Howell Post-Hoc Test. The findings indicated that student responses varied significantly across different teaching styles—Demonstrate, Facilitate, and Delegate. The ANOVA results showed significant differences in students' programs of study across the teaching preference classes ($F = 10$, $p < 0.001$). The post-hoc analysis revealed a significant difference between the Demonstrate and Delegate groups ($t = -4.45$, $p < 0.001$), suggesting distinct preferences in how these students approach mathematics learning based on the teaching strategies employed. These results suggest the importance of tailoring teaching styles to students' learning preferences to enhance mathematics outcomes.

Keywords: Latent Class Analysis, Teaching, Learning, Education, Preference

Introduction

Mathematics is a critical subject that forms the foundation for many academic and professional fields. It is often viewed as a challenging subject, and students' attitudes and preferences towards how it is taught can significantly impact their engagement and achievement (Anthony & Walshaw, 2009). Understanding student preferences for teaching styles can help educators tailor their approaches to better meet the needs of their students, thereby improving their learning experiences and outcomes (Cardino & Ortega-Dela Cruz, 2020). Previous studies have shown that different teaching styles can significantly impact student performance in mathematics. For example, Cardino and Ortega-Dela Cruz (2020) found that personalized teaching approaches, which consider individual learning styles, can enhance student performance in mathematics. Different teaching styles, such as direct instruction, collaborative learning, and the use of technology-enhanced teaching, cater to different types of learners (Valle et al., 2003). However, traditional approaches to studying these preferences often fail to capture the complexity of student experiences and the heterogeneity within student populations (Luyten, et al., 2017). According to Goodman (1988), Latent Class Analysis (LCA) emerged around the 20th century, with foundational contributions by Lazarsfeld (1950), who introduced the concept to explain patterns in survey responses in 1950.It has then been further developed by some researchers and notable among them was Goodman who applied it to nominal variables and creating the maximum likelihood algorithm, enhancing its practicality. Since its inception, LCA has evolved into a widely utilized method across various disciplines for identifying unobserved subgroups within populations (Lazarsfeld, 1950; Goodman, 1988). In LCA, the idea of modeling data as a mixture of distributions was developed in the 1950s. These models assume that data come from a mixture of several

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distributions, each representing a different subgroup or class within the population. Latent Class Analysis itself was formalized in the late 1970s and early 1980s. The work of researchers such as Norman R. Forthofer, Robert R. McCutcheon, and others helped to establish LCA as a distinct and useful technique. McCutcheon's work in particular provided a comprehensive framework for applying LCA in social science research. Latent Class Analysis, (LCA) is a statistical method used to identify subgroups within a population that share similar characteristics. In education, LCA can be used to classify students based on their preferences for different teaching styles. This method allows researchers to uncover hidden patterns in student preferences, providing valuable insights for developing more effective teaching strategies (Lin & Tai, 2015). LCA offers a robust methodological approach to address a gap in different teaching styles. It can also be defined as a person-centred statistical technique that identifies subgroups within a population based on their responses to various indicators (Vermunt & Magidson, 2002).

In the context of a College of Education, where future teachers are trained, this type of research is particularly relevant so as to ensure that the correct things are being handed to them. By identifying latent classes of student preferences for teaching styles in mathematics, teacher educators can develop more targeted and effective instructional strategies. This not only enhances the learning experience for students but also prepares pre-service teachers to implement differentiated instruction in their future classrooms (Kane, Shaw, & Pang, 2018). Implications for Mathematics Teaching: The application of LCA in identifying student preferences provides valuable information for educators. By tailoring teaching methods to align with the identified preferences, educators can enhance student engagement and performance. This approach aligns with the findings of previous studies, which emphasize the importance of adaptive teaching strategies in improving mathematical literacy (Lin & Tai, 2015; Cardino& Ortega-Dela Cruz, 2020). Research consistently highlights the impact of teaching styles on student learning outcomes (e.g., Hattie, 2012). Studies have explored various dimensions of teaching styles, including teacher-centred vs. student-centered approaches, direct instruction vs. inquiry-based learning, and cognitive, behavioural, and affective domains (Kember&Gow, 1993; Felder & Silverman, 1988). While quantitative and qualitative studies have provided valuable insights, the complexity of student preferences often necessitates more sophisticated analytical methods.

Latent Class Analysis in Education: LCA has gained traction in educational research as a means to identify unobserved subgroups or latent classes based on observed variables (Goodman, 1988). It has been employed to explore student characteristics, learning styles, and attitudes (McLachlan & Peel, 2000). They also utilized LCA to identify distinct profiles of student engagement in online learning.
Student Preferences in Mathematics Education: Within the realm of mathematics education, research has examined student preferences for teaching styles, often focusing on factors such as age, gender, and academic achievement (e.g., Shaughnessy, 2007). However, the application of LCA to uncover latent classes of students based on their mathematics teaching style preferences is relatively scarce.

Statement of the Problem

Mathematics is a critical subject that forms the foundation for many academic and professional fields. However, it remains a subject that many students find challenging and difficult to master, particularly in higher education. The success of students in mathematics is influenced not only by their inherent abilities but also by the teaching styles employed by educators. In colleges of education, where future teachers are trained, the effectiveness of different teaching strategies in mathematics becomes particularly important, as these future educators will carry these strategies into their classrooms. Research has shown that students' preferences for teaching styles can significantly impact their engagement, performance, and overall attitude toward mathematics. However, the problem is that traditional teaching methods often fail to address the diverse learning preferences of students. Many educators continue to use a one-size-fits-all approach to teaching, which may not effectively support all students. As a result, some students excel, while others struggle to grasp core mathematical concepts. In the context of teacher education, it is essential to understand which teaching styles are most effective for diverse student populations. Despite the growing awareness of differentiated instruction, little attention has been given to the application of Latent Class Analysis (LCA) to identify subgroups of students based on their preferences for different teaching styles in mathematics. Furthermore, there is limited research exploring the relationship between teaching styles and student outcomes in mathematics learning, particularly in the unique environment of colleges of education.

This study seeks to fill this gap by employing LCA to identify distinct latent classes of students based on their preferences for three teaching styles: Demonstrate, Facilitate, and Delegate. By doing so, the study aims to provide a deeper understanding of how teaching strategies influence mathematics learning outcomes among student teachers and to offer insights into how mathematics instruction can be tailored to better meet the needs of diverse

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learners. Understanding these preferences will help educators in colleges of education refine their teaching approaches, ultimately improving the quality of mathematics education and better preparing future teachers to meet the needs of their students.

While previous research has shed light on student preferences in mathematics education, there is a paucity of studies employing LCA to explore these preferences within a college of education setting. By identifying distinct latent classes of students based on their teaching style preferences, this study contributes to a deeper understanding of student heterogeneity and informs the development of tailored instructional strategies. The study explored the preferences for teaching styles in mathematics learning among undergraduate students in a college of education, seeking to achieve two primary objectives. The study contributed knowledge that can inform the development of tailored pedagogical strategies for enhancing mathematics education in higher education institutions.

Objectives of the study

The study is set to evaluate students' responses across different teaching styles (Demonstrate, Facilitate, Delegate) regarding the impact of teaching strategies on mathematics learning outcomes and determine the distribution of teaching preferences across different teaching styles for mathematics learning.

Research Questions:

1. How do students' responses vary across different teaching styles (Demonstrate, Facilitate, Delegate) regarding the impact of teaching strategies on mathematics learning outcomes?
2. What is the distribution of teaching preferences across different teaching styles for mathematics learning?

Hypothesis:

H_{01}: There are no significant differences in students' programmes of study across teaching preference classes.

Methodology

The study employed a quantitative research approach focusing on the use of descriptive survey design. The study participants include all level 400 student teachers of the 2023/2024 academic year. These participants were purposively sampled based on the fact that they have experienced the mandatory four years of the B.Ed. Programme in college and have identified their preferred learning style as far as mathematics courses are concerned. In all, we have 1489 but only 1338 of them successfully submitted their questionnaire. This constitutes 89.86% of the population, therefore accepted for the study to be conducted. The sample was obtained from three Colleges of Education in the Volta region of Ghana, which are affiliated with the University of Cape Coast in Ghana. The instrument used for this study is titled Student Preference for Learning Mathematics Questionnaire (SPLMQ). It comprises ten (10) items and is patterned in three (3) Likert-scale: Disagreed (1), Don't know (2) and Agreed (3). The instrument was prepared, validated and administered to a set of all participants stated above. The data analysis for the study included fit indicators, LCA plots, Descriptive and Inferential Analysis of a one-way ANOVA, Class item response probability, Games-Howell Post-Hoc Test of multiple pairwise comparisons of the mean differences

Results

Table 1: Fit indicators and criteria for determining the class model to be selected

Class	AIC	BIC	Entropy	G^2	χ^2
2	20850	21064	0.740	4156	120455
3	20708	21030	0.628	3972	148811
4*	20586	21018	0.695	3808	109943
5*	20524	21064	0.675	3703	43589
6*	20503	21153	0.666	3641	76252

In table 1, the 4-class model has AIC = 20586, BIC = 21018, and entropy = 0.695, while the 5-class model has slightly lower AIC and BIC values (AIC = 20524, BIC = 21064) and entropy = 0.675. Despite the lower AIC in the 5-class model, the improvement is marginal compared to the 4-class model, which maintains better entropy. Hence, the first 3-classes model is considered the best fit based on these criteria.

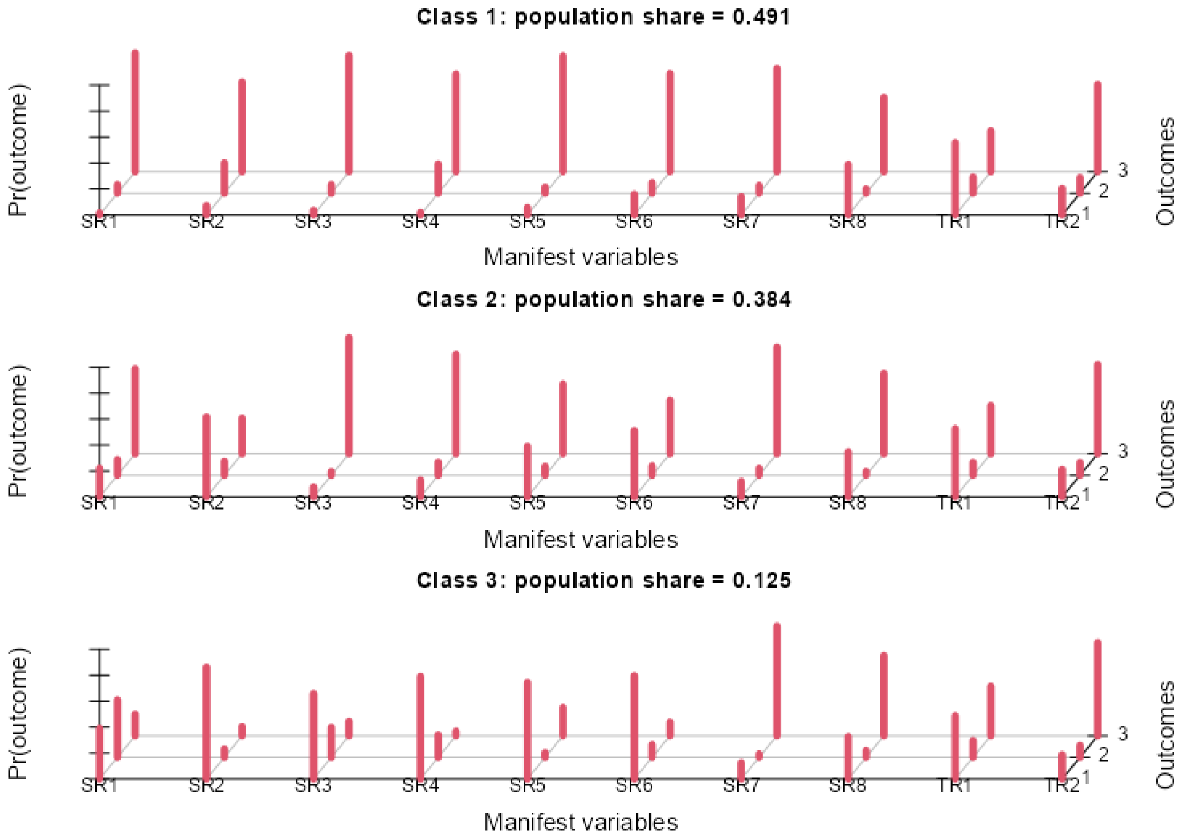

Fig. 1: LCA plot

Figure 1 presents LCA plot to visualize the distinctions between latent classes, showing how students cluster based on their preferences for teaching strategies. The separation between the classes is clear, with each class exhibiting distinct patterns of teaching strategy preferences.

RQ1. How do students' responses vary across different teaching styles (Demonstrate, Facilitate, Delegate) regarding the impact of teaching strategies on mathematics learning outcomes?

To answer the research question, the focus is on analysing the relationship between students' preferences for teaching styles and their responses to various mathematics learning outcomes. Table 2 provides estimated class-item response probabilities for each teaching style, showing how students perceived the impact of teaching strategies on their learning. It shows that Demonstrating and Facilitating teaching and learning styles are strongly associated with students' improved understanding of mathematics. Nearly 40% of students who prefer the Demonstrate style agree that it enhances their understanding, while Facilitate performs even better with a 44.3% agreement. Delegate, however, receives overwhelmingly negative responses, with 91.6% of students disagreeing that it improves their understanding. The Demonstrate strategy leads to significant improvements in students' performance in mathematics assessments, with 86.3% agreeing that it helps. In contrast, Delegation is ineffective, with nearly 70% of students disagreeing that it improves their performance. Facilitating yields moderate disagreement, suggesting some impact but less effectiveness than Demonstrating.

Confidence in solving mathematical problems is strongly boosted by the demonstrated teaching style, with over 65% agreeing. Facilitate also contributes to increased confidence, though less strongly. Delegate is again perceived negatively, with almost 90% of students disagreeing that it improves their confidence. The Demonstrate strategy has a highly positive influence on overall mathematics achievement, with nearly 80% of students agreeing. The Facilitate strategy also contributes but is less effective. Delegate shows a stark contrast, with only 3.6% agreeing that it positively influences achievement. The Demonstrate strategy effectively supports students' approach to solving mathematical problems, with 74.5% of students agreeing. Facilitate performs poorly here, and Delegate is once again perceived negatively, with 89.4% of students disagreeing. Applying mathematical concepts to real-life situations is highly supported by the demonstrated strategy, with nearly 80% agreement.

Delegate is seen as the least effective, with more than 75% disagreement. Interestingly, the Delegate strategy is seen to facilitate retention and recall of mathematical knowledge, with 84.6% of students agreeing. However, Demonstrating and Facilitating appear much less effective in this regard. Critical thinking skills are significantly enhanced by the Delegate strategy, with 61.9% agreement. Demonstrate also contributes, but a substantial proportion of students disagree that it enhances critical thinking. Delegate has a stronger positive effect on motivation compared to Facilitate, with 38.2% agreement. However, Demonstrate still maintains a significant influence, with 48.8% agreement, despite a high rate of disagreement. Delegate is strongly associated with providing a structured approach to studying mathematics, with 71.9% agreement. The Demonstrate strategy is less effective in this area, and Facilitate is perceived to offer little structure.

RQ2. What is the distribution of teaching preferences across different teaching styles for mathematics learning?

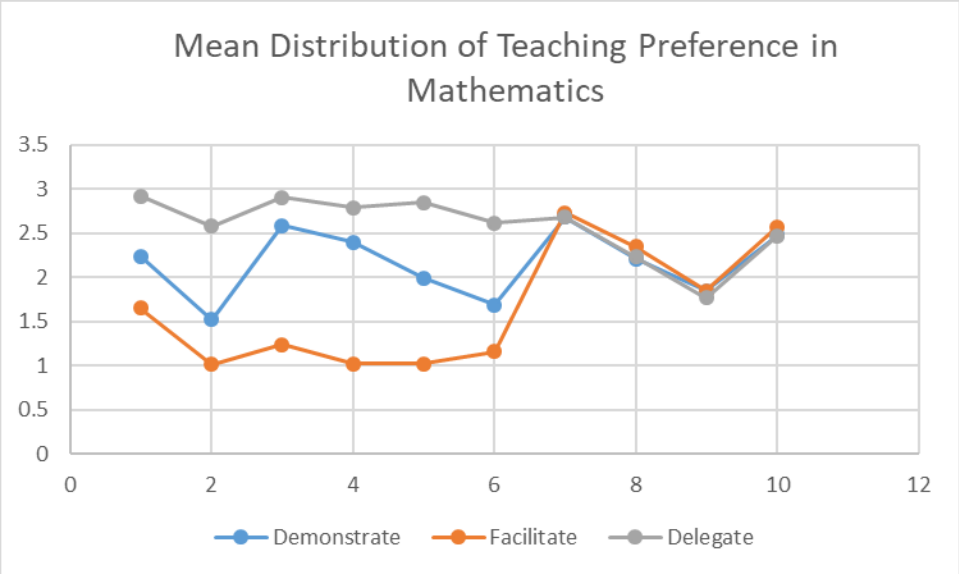

Fig 2: Mean Distribution of Teaching Preference in Mathematics

The mean distribution plot in Figure 2 shows variability across the three teaching preferences, with Delegate showing consistently higher means compared to Demonstrate and Facilitate.

H_{01}: There are no significant differences in students' programmes of study across teaching preference classes.

Table 3: Descriptive and Inferential Analysis of a one-way ANOVA (Welch's) showing the mean differences in Students Program of Study among different classes of Teaching Preference in Mathematics

	Mean	SD	F	df1	df2	p
Demonstrate (N=489)	1.76	0.791	10	2	279	< .001
Facilitate (N=100)	1.84	0.788				
Delegate (N=749)	1.97	0.855				

The ANOVA result shows a significant F-value (F = 10, p = 0.001 < 0.05), indicating that there are significant differences in students' programs of study across teaching preference classes. The magnitude and directions of significance are determined by the Games-Howell Post-Hoc Test of multiple pairwise comparisons and the results are as presented in Table 4.

Table 4: Games-Howell Post-Hoc Test of multiple pairwise comparisons of the mean differences in the Program of Study on the classes of Teaching Preference in Mathematics

(I) Class	(J) Class	t - value	df	p-value
Demonstrate	Facilitate	-0.916	143	0.631
	Delegate	-4.45	1099	< .001
Facilitate	Delegate	-1.56	132	0.268

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The post-hoc test reveals a significant difference between the Demonstrate and Delegate classes (t = -4.45, p < .001), suggesting that students' programs of study differ significantly between these two groups.

Discussion

The model selection indicates that the 4-class structure captures the underlying latent variables in the data effectively. Although the 5-class model provides a slightly better AIC and BIC, the difference in entropy suggests that the 4-class model maintains a clearer separation of classes. This finding substantiates the assertion of Cardino and Ortega-Dela Cruz (2020) who remarked that understanding student preferences for teaching styles can help educators tailor their approaches to better meet the needs of their students, thereby improving their learning experiences and outcomes. The findings also present a clear breakdown of how students' learning experiences differ based on their preferences for teaching styles. The findings suggest that Demonstrate and Facilitate teaching styles are more positively associated with various mathematics learning outcomes, including understanding, performance, confidence, and overall achievement. Students who prefer the Delegate style, however, tend to report less favourable outcomes across most categories. This is in agreement with the idea of Cardino and Ortega-Dela Cruz (2020) that different teaching styles can significantly impact student performance in mathematics and found that personalized teaching approaches, which consider individual learning styles, can enhance student performance in mathematics.

Besides, the key takeaway from the findings is that Demonstrate is the most effective teaching style in improving mathematics learning, as evidenced by higher probabilities of agreement across multiple learning outcomes. In contrast, delegation appears to be less effective, particularly in areas related to understanding, confidence, and performance. This insight could guide future educational strategies by suggesting that the Demonstrate style may be more effective in promoting positive learning experiences in mathematics, while the Delegate might need to be supplemented with additional support to achieve similar outcomes. This is in consonance with the impressions of Valle et al. (2003) and Luyten et al. (2017) who observed in their different studies that different teaching styles, such as direct instruction, collaborative learning, and the use of technology-enhanced teaching, cater to different types of learners and, traditional approaches to studying these preferences often fail to capture the complexity of student experiences and the heterogeneity within student populations. Moreover, the LCA plot supports the fact that there are clear distinctions between the classes. The different groupings suggest that students' experiences and preferences are shaped by the type of teaching strategies employed, which aligns with the previously tested item-response probabilities. This aligns with the notions of Lin and Tai (2015) and Vermunt and Magidson (2002) where it was postulated that LCA can be used in education to classify students based on their preferences for different teaching styles as the method allows researchers to uncover hidden patterns in student preferences, providing valuable insights for developing more effective teaching strategies because Latent Class Analysis (LCA) offers a robust methodological approach to address a gap in different teaching styles since it can be illustrated as a person-centred statistical technique that identifies subgroups within a population based on their responses to various indicators.

The ANOVA analysis reveals that students' programs of study differ significantly based on their teaching preferences. This suggests that certain teaching styles might be more prevalent or effective in particular academic programs, providing insights into curriculum development and instructional strategies tailored to students' needs. This approach aligns with the findings of previous studies (Lin & Tai, 2015; Cardino& Ortega-Dela Cruz, 2020), which emphasize the importance of adaptive teaching strategies in improving mathematical literacy and advised that by tailoring teaching methods to align with the identified preferences, educators can enhance student engagement and performance. The post-hoc analysis supports the hypothesis that there are significant differences between the Demonstrate and Delegate classes. This further highlights the importance of considering individual preferences in teaching strategies when designing programs to enhance student learning outcomes. This finding is consistent with those of Hattie (2012); Kember and Gow (1993) and Felder and Silverman (1988), who highlighted the impact of teaching styles on student learning outcomes and explored various dimensions of teaching styles, including teacher-centered vs. student-centered approaches, direct instruction vs. inquiry-based learning, and cognitive, behavioral, and affective to provide valuable insights into the complexity of student preferences which often necessitate more sophisticated analytical methods. This study also showed that the distribution is not uniform, as Delegate has higher means across most of the variables, indicating that students who prefer delegation tend to rate teaching strategies more favourably. This suggests that certain teaching methods may be more effective for specific groups of students, supporting differentiated instruction approaches. This is in line with Shaughnessy's (2007) finding that, within the realm of mathematics education, there are students' preferences for teaching styles.

Conclusion

This research describes how different teaching styles influence students' mathematics learning experiences. The findings emphasize the importance of understanding student preferences and adapting teaching methods accordingly to improve learning outcomes. Future educational strategies should prioritize the Demonstrated teaching style while offering support for the Delegate, particularly for students who respond better to this method. Tailoring teaching approaches to individual learning preferences will likely yield the best results in fostering mathematical literacy and achievement.

Recommendations

Based on the findings of this study, the following recommendations are suggested:

1. Demonstrate: Educators should prioritize the use of the demonstrated teaching style in mathematics lessons, integrate visual aids such as diagrams and charts, and receive training on how to effectively implement these strategies.
2. Delegate: The Delegate approach should be minimized for foundational mathematical topics that require thorough explanation, and when used in collaborative work, teachers should provide clear guidelines, periodic check-ins, and active monitoring.
3. Facilitate: The facilitator style should encourage active student participation by incorporating inquiry-based learning, structured support for difficult topics, and increased feedback sessions to enhance engagement and learning outcomes.

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Appendix

Table 2: Estimated class-Item response probabilities

Items: Student Mathematics Learning Experience and Response based on Preference for Teaching Styles		Demonstrate 49.1% (n = 689)	Facilitate 38.4% (n = 487)	Delegate 12.5% (n = 162)
1. The utilization of teaching strategies has enhanced my understanding of mathematics.	Disagree	0.017	0.067	0.916
	Don't Know	0.223	0.122	0.655
	Agree	0.392	0.443	0.165
2. Teaching strategies have improved my performance in mathematics assessments.	Disagree	0.072	0.235	0.693
	Don't Know	0.618	0.108	0.274
	Agree	0.863	0.066	0.072
3. Teaching strategies has increased my confidence in solving mathematical problems.	Disagree	0.036	0.067	0.897
	Don't Know	0.076	0.028	0.896
	Agree	0.658	0.231	0.111
4. The use of teaching strategies has positively influenced my overall mathematics achievement.	Disagree	0.020	0.226	0.755
	Don't Know	0.130	0.101	0.769
	Agree	0.791	0.173	0.036
5. Teaching strategies have helped me approach mathematics problems more effectively.	Disagree	0.057	0.049	0.894
	Don't Know	0.391	0.070	0.539
	Agree	0.745	0.037	0.219
6. Teaching strategies has improved my ability to apply mathematical concepts to real-life situations.	Disagree	0.159	0.082	0.759
	Don't Know	0.512	0.074	0.414
	Agree	0.797	0.099	0.105
7. Teaching strategies have facilitated my retention and recall of mathematical knowledge.	Disagree	0.142	0.062	0.797
	Don't Know	0.121	0.056	0.823
	Agree	0.126	0.028	0.846
8. Teaching strategies has enhanced my critical thinking skills in the context of mathematics.	Disagree	0.391	0.036	0.574
	Don't Know	0.350	0.031	0.620
	Agree	0.327	0.054	0.619
9. The use of learning strategies has positively impacted my motivation to learn and excel in mathematics.	Disagree	0.559	0.126	0.315
	Don't Know	0.528	0.100	0.372
	Agree	0.488	0.131	0.382
10. Teaching strategies have provided me with a structured approach to studying mathematics.	Disagree	0.205	0.122	0.673
	Don't Know	0.213	0.099	0.688
	Agree	0.188	0.093	0.719

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